Review of the Report: "Abundance of the coastal morphotype of bottlenose dolphin, *Tursiops truncates,* in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002".

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Executive Summary

The coastal bottlenose dolphins on the West Atlantic seaboard of the U.S. are currently classified as depleted, and by-catch mortality is at a sufficient level that a Take Reduction Team has been formed. In order to properly manage this problem, precise estimates of the population size of the coastal bottlenose dolphins must be obtained. These estimates are made difficult by the fact that, over at least part this species' range, its distribution overlaps with the offshore morphotype of bottlenose dolphin over the continental shelf. The offshore form is a distinct morphotype or ecotype that is effectively isolated genetically from the coastal form. The two morphotypes are very difficult to distinguish during aerial surveys and so estimates of the abundance of coastal bottlenose dolphins may be biased upwards by the presence of the offshore form among the coastal groups. In the present assessment (Garrison *et al*, 2003), an analytical strategy has been adopted of estimating the total abundance of bottlenose dolphins and then correcting these estimates to account for the spatial pattern of the distribution of the two morphotypes. In addition to the two morphotypes, a degree of heterogeneity has been recognized among populations along the U.S. coastline, although the implied stock status of these sub-populations is still only preliminary. This separate analysis has led to a number of management units being identified, which form the focus of the sampling design for the surveys made on the bottlenose dolphin. There is some migration between these management units in the winter. The spread of the populations among these management units is clearer in the summer; indeed the winter abundance estimates appear to be consistently lower than those in the summer. The separation of the coastal and offshore morphotypes is also clearer in the summer. Given these two advantages, assuming there are no reasons not apparent to the reviewers, it may be sensible to determine whether the winter surveys could be scrapped and the summer surveys extended to improve the overall estimates.

The aerial surveys, used to produce abundance estimates for the bottlenose dolphins along the West Atlantic U.S. coastline, were well designed, well executed and appropriately analyzed. The latest design is a significant advance over earlier surveys in that perception bias is accounted for and the track-lines of the aerial survey appear to be more representative of the available habitat. There were limited numbers of transects flown over the outer, deeper stratum in some of the more southerly management units, which may place a limit on the precision of the estimates for those areas. However, the size of the populations in the effected units was relatively small so this is unlikely to be very important.

The statistical methodologies used to distinguish the spatial distribution and habitats of the coastal and offshore morphotypes of the bottlenose dolphins were appropriate, especially for the more southerly management units. The analysis was complicated by the fact that in the northern most management units, especially in the summer, the two morphotypes did not appear to overlap in their distribution across the continental shelf. The difficulty for the analysis was that the process being described was categorical in the north but continuous in the south. Thus, the use of natural splines to describe changes in density across the shelf was reasonable in the southerly management units but was redundant in the north.

Adding the available genetic information to the spatial information rightly suggested that a logistic regression be used to describe the decreasing gradient of the coastal morphotype and the increasing gradient of the offshore morphotype across the continental shelf. While this description appeared to be completely appropriate, a shortage of genetic data, especially in the winter period, meant that the analysis was relatively uncertain. In the northernmost

management units in the summer, it was appropriately recognized that the spatial analysis was all that was required to complement the estimates of the coastal morphotypes abundance.

There were good discussions of potential biases in the assessment document, both minor sources and major. There were at least three critical sources of potential bias:

1. There is a lack of genetic information to precisely separate the distribution of the coastal and offshore morphotypes, where that was necessary (could be a positive or negative bias).
2. There is a lack of an assessment of the abundance of bottlenose dolphins in estuarine waters (a negative bias if the animals in estuaries are part of the coastal bottlenose dolphin stock).
3. Uncertainties in the description of the population heterogeneity within the coastal morphotype mean that the management units may not be well defined. This lack could lead to the sampling design used over-sampling some areas and under-sampling others.

Where uncertainty in the analyses could be captured, it has been effectively included. The use of the bootstrap method permitted an assessment of uncertainty even when the analyses were non-linear and not necessarily additive; other methods would most likely have been inadequate. However, because there was no information concerning some of the potential sources of bias (e.g. estuarine populations) there was no way that the abundance estimates could properly include indications of the uncertainty in the analyses relating to these sources. Nevertheless, where biases could not be explicitly included they were invariably negative so the conclusions could be considered precautionary.

The assessment of the abundance of the coastal morphotype of bottlenose dolphin described in Garrison *et al* (2003) is an ambitious piece of work, which, given the practical constraints and the limited availability of genetic information, has been well executed and provides the best available estimates. This work is a significant advance over earlier estimates. By suggesting increased biopsy sampling, the authors recognize where the estimates could be most significantly improved.

Background

Statement and History of the Problem

The bottlenose dolphin, *Tursiops truncates*, commonly occurs in estuaries, inshore coastal waters, and in continental shelf waters along the east coast of the United States. Unfortunately, during 1987-1988, a major die-off occurred along the entire U.S. Atlantic coast leading to a significant decline in the total bottlenose dolphin population. At the time, this decline was thought to drop the population to approximately 47% of pre-1987 levels. However, a more recent analysis (Eguchi, 2002) suggests that the population may have dropped to only 10-27% of pre-1987 levels. This naturally induced die-off (classed as an epizootic event) eventually led, in 1993, to the western North Atlantic coastal bottlenose dolphin stock being classified as depleted under guidelines provided in the Marine Mammal Protection Act. This depleted status implies that the level of any human-induced mortality formerly deemed acceptable, will be greatly reduced relative to that prior to the stock depletion.

Regrettably, there is a certain level of bycatch mortality because of an interaction between commercial fishing operations, especially gill-netting, and the coastal stock of Atlantic bottlenose dolphin. In 1994, amendments made to the Marine Mammal Protection Act required that the Potential Biological Removal (PBR) levels of all marine mammal stocks within the U.S. Exclusive Economic Zone be compared with estimates of the annual human-induced mortality levels. If the annual take is greater than the estimated PBR, then various responses are required, including the creation of a Take Reduction Team tasked with devising strategies for reducing the human-induced mortality. The Potential Biological Removal (PBR) is described as the number of animals that can be removed from a population and still permit recovery of a depleted stock or the maintenance of a stock at its optimum and sustainable size. The calculation of the PBR requires an understanding of the stock structure of the population or populations concerned, along with estimates of population abundance that include explicit estimates of the uncertainty associated with the analysis.

The stock structure of the populations concerned is required in order to correctly identify the particular population or populations that are depleted and under threat from human-induced mortality. The stock structure of the western North Atlantic coastal bottlenose dolphin has a number of aspects that add complications to the assessment of population abundance. There is evidence that there are a number of genetically and/or behaviourally distinct stocks of coastal bottlenose dolphin on the U.S. Atlantic coast. Certainly there are distinctive coastal and offshore morphotypes (NMFS, 2001). There is morphological, genetic, and haematological evidence suggesting that the two morphotypes experience little or no genetic exchange and may even be considered as different species (NFMS, 2001). On top of the separation of the coastal from the offshore morphotypes, the optimum description of the heterogeneity in behaviour, genetics, and other details led to seven management units being defined in the summer (Northern Migratory, Northern North Carolina, Southern North Carolina, South Carolina, Georgia, Northern Florida, and Central Florida; Figure 1 in Garrison *et al*, 2003). The northern most animals retreat south in the winter, staying in waters of approximately 10^{o}C or more. In the winter, the coastal bottlenose dolphin population contracts into the southern most six management units, with the top three management units being mixed and referred to as the Northern Migratory and northern North Carolina Unit, which overlaps with the southern North Carolina Management Unit (Figure 1 in Garrison *et al*, 2003). As most of the population is found in the northern-most management unit in summer and winter, these are areas of special significance in the following work.

The most convincing evidence for spatial structuring of the coastal morphotype population is the genetic analysis of mitochondrial DNA and of nuclear micro-satellites (NMFS, 2001). However, the samples are relatively small for such a patchily distributed species that occurs in groups, and there are no samples from the northern most management units (Table 1: NMFS, 2001). The degree to which the population is thought to be spatially structured affects the sampling design of the aerial surveys and all associated sampling. Hence, the implied stock structure of the coastal morphotype suggested by the seven management units is a major source of uncertainty in this study of stock abundances.

Ignoring the estimates of human-induced mortality, there are two critical aspects of this process: 1) the understanding of the stock structure, and 2) the estimate of population size. The focus of this review is primarily on the latter in the form of the document by Garrison *et al* (2003), which describes the abundance estimates made of the coastal stocks of bottlenose dolphin, and includes a detailed discussion of the spatial distribution of the coastal and offshore morphotypes.

Review Activities

The review initially was to have occurred and been completed by 17th February 2003. However, there were unavoidable delays in making the required documents available for review, and so the number of documents made directly available was greatly reduced and the review time-frame extended by two weeks. Under the Statement of Work below, there is an appendix of materials that were to have been made available on bottlenose dolphin science and their stock structure. Details of the review web-site, from which documents could be downloaded, were sent by email on the 11th of February 2003 (in Australia). At that time, there were three documents present on the web-site. On the 15th of February 2003 (in Australia), the abundance report to be reviewed also arrived by email and was, at the same time, made available at the review web-site. Four documents were immediately available:

Garrison, L. and C. Yeung (2001) Abundance Estimates for Atlantic Bottlenose Dolphin Stocks During Summer and Winter, 1995. Southeast Fisheries Science Center, Miami Laboratory June 15, 2001. as Garrison_Yueng_Abundance.pdf

Garrison, L. (2001) Seeking a Hiatus in Sightings for Bottlenose Dolphin during Summer and Winter Aerial Surveys. Southeast Fisheries Science Center, National Marine Fisheries Service for the Take Reduction Team on Coastal Bottlenose Dolphins in the Western Mid-Atlantic. as Garrison_Spatial_Gap_Analysis.pdf.

NMFS (2001) Preliminary Stock Structure of Coastal Bottlenose Dolphins along the Atlantic Coast of the US. Prepared by Staff, Southeast Fisheries Science Center, National Marine Fisheries Service for the Take Reduction Team on Coastal Bottlenose Dolphins in the Western Atlantic. as Stock Structure of Coastal Bottlenose Dolphins.pdf (containing Garrison 2001 as an appendix)

Garrison, L., Rosel, P.E., Hohn, A., Baird, R., and W. Hoggard (2003) Abundance of the coastal morphotype of bottlenose dolphin, *Tursiops truncatus*, in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002. NOAA Fisheries, Southeast Fisheries Science Center, 75 Virginia Beach Dr. Miami FL 33149. as Bottlenose_Dolphin_Abundance_2002.pdf

These documents are also listed under the references section, along with a very few other documents that were obtained by other means. Unfortunately, in the generation of the PDF version of one of the major supporting document (NFMS, 2001) an error occurred that led to significant amounts of text being accidentally hidden. This document was corrected and replaced on 26th February.

The emphasis of the review was on the final document listed above, (Garrison *et al* 2003), with instructions to focus particularly on:

1. The appropriateness of the design, execution, and analysis of the aerial surveys used to derive abundance estimates for bottlenose dolphins in the mid-Atlantic.

2. The appropriateness of the statistical methodologies used to distinguish the spatial distribution and habitats of coastal vs. offshore morphotype bottlenose dolphins.

3. The appropriateness of the resulting abundance estimate for coastal morphotype bottlenose dolphins from combined genetic data, spatial distribution information, and aerial survey data.

4. Determine if potential biases have been adequately identified and whether appropriate measures of statistical uncertainty have been included in the resulting abundance estimates.

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Summary of Findings

Structure of Document and Review

The most recent abundance estimation document (Garrison *et al*, 2003) is structured into four main sections that simplify the job of reviewing its contents. The first section deals with the spatial distribution of bottlenose dolphins as a function of habitat variables for all seven management units and both summer and winter distributions. The second section deals with quantitatively characterizing the spatial distribution of the two morphotypes of bottlenose dolphin in such a way that the abundance estimates may be corrected for the mixing of the two morphotypes observed within parts of the surveyed area. The third section details the methods and results of the individual surveys conducted in the seven management units at different times of the year. The fourth and final section draws the results of the previous sections together to produce an overall abundance estimate. In the final section, the quantitative characterization of the spatial distribution of the two morphotypes is combined with the estimates of total bottlenose abundance to provide estimates of the abundance of just the coastal morphotypes bottlenose dolphin. In addition, the sources of uncertainty and bias are discussed and described where possible.

Common to all analyses were a variety of surveys, including aerial surveys of abundance and vessel based surveys for collecting biopsy samples. Prior to discussing the four sections, the survey designs and methodologies will be considered, as this matches the structure of the document (Garrison *et al*, 2003) and prepares the way for the detailed consideration of the four sections.

Survey Design and Methodology

Aerial Visual Line Transect Surveys

Both the winter (15 Jan 2002 – 28 Feb 2002) and summer (15 Jul 2002 – 31 Aug 2002) Visual Line Transect surveys were conducted with essentially the same design. Because the winter survey encompassed a smaller geographical area, the sampling intervals along the coast were closer together. This was a reasonable response to the greater densities expected to occur in the survey area in the winter, especially in the more northerly areas. Achieving almost 85.5% of the planned survey in the winter was an excellent result considering that, even in the summer, the survey could complete only 88.5% of the planned trackline. The survey protocols followed are standard and given the geographical scale of the survey would be difficult to improve upon. The design of the survey aircraft, especially with the addition of the bubble observation windows, must have provided an excellent platform for conducting this ambitious visual survey.

The survey track-lines were angled to be approximately perpendicular to the bathymetry gradient in an attempt to provide a representative sample of animal density across the habitat variables thought to be important within the survey area. This method was a significant improvement over the survey track-lines conducted in the winter 1995 survey of the Georgia, Northern and Central Florida management units, which did not always appear to be conducted perpendicular to either the coastline or the bathymetry (Garrison & Yeung, 2001; Figure 3, p12). Because there is a close correlation between bathymetry and distance from the shore, subsequent analyses in Garrison *et al*. (2003) found these two factors to provide almost the same amount of information. Nevertheless, by sampling in this way, it was possible to obtain unbiased samples of dolphin densities relative to the coast.

The use of two independent observation teams in the same aircraft provided important information with regard to perception bias and, where perception bias is confounded with visibility bias, partly towards visibility bias. Perception bias is where different observers, each having different experience, will have different success rates at observing dolphin groups. Visibility bias is where the probability of spotting a group varies with time so that equally effective observers may have varying success depending on whether or not members of a dolphin group are on the surface or not. Both of these sources of bias tend to lead to reduced estimates of abundance (both are negative biases). The results in the third section, where the estimates are all increased once perception bias is accounted for, illustrate the value of obtaining as much information about these biases as possible. The methodology adopted is probably as good as the limits of what was/is practical permitted. Ideally, the plexiglass bubble windows used by the observers in each team should have been of identical design. Some of the differences between the observation teams would have been due to each using a slightly different viewing schema (Figure 4; Garrison *et al*, 2003). However, data from both teams appears to have been treated together to provide the estimates of the sighting probability functions so the assumption is that the sighting function was essentially the same for each team (Figures 31 & 32, Garrison *et al*, 2003), that is, the effects of the different viewing schema appear to have been minimal.

Dealing more completely with visibility bias is complicated because if two separate teams are used then the confounding between perception bias and visibility bias means that ideally there would have to be two aircraft conducting independent but identical surveys, each plane having two independent observation teams, as in the present survey. There would have to be only a small number of nautical miles between the aircraft to ensure that identified groups could be correctly correlated. In this way it might be possible to estimate the separate components of perception bias and visibility bias. Such an arrangement would have doubled to cost of the surveys (at least) and given that the visibility bias was considered to have been relatively small this would have been unnecessary. Visibility bias was considered to be small because the dolphin groups tended to be made up of sufficient animals that at any time at least one animal would be on the surface breathing. Other sources of bias associated with the quantitative estimation of the overlap of coastal and offshore morphotypes are likely to be much greater than the visibility bias and thus should be most urgent for further work.

Biopsy Collection Surveys

The two morphotypes can be easily distinguished using standard genetic techniques (NMFS, 2001). The best way, therefore, of characterizing the spatial distribution of the two forms would be to obtain biopsy samples from individuals across the depth ranges of the species in summer and winter and across the latitudinal range of their distributions. Ideally, these samples would be distributed in proportion to the relative abundance of the dolphins in the water. However, the practical difficulties of obtaining such samples are very great. Using large vessels had the disadvantage that getting close enough to the animals to obtain biopsy samples was difficult; in addition, the depth distribution of samples was biased to somewhat deeper waters because of the operational limits of the vessels. The authors of the document under review (Garrison *et al*, 2003) appear well aware that the biopsy samples currently available can only provide relatively uncertain estimates of the spatial distribution of the two morphotypes. They state clearly and this reviewer is in agreement, that improved information on morphotypes distribution can only serve to improve the overall abundance estimates of the coastal morphotypes of the bottlenose dolphin.

General Comments on the Surveys

The population of coastal bottlenose dolphins is at least partly migratory. The surveys to date demonstrate that the majority of the population is found in the more northerly management units in both the summer and the winter. If the objective is to obtain the best possible estimate of population size in each management unit then the question arises of whether it is necessary to repeat the surveys in both the summer and the winter. Certainly, the confidence intervals of the population abundance estimates from the summer and winter overlap, but the winter estimates all appear lower than the summer ones, suggesting some possible negative bias still to be identified. It would appear that the separation of the two morphotypes in the summer is clearer than in the winter so there may be significant advantages to focussing resources into optimising a summer survey. This notion of a single seasonal survey would need to be rejected if the Potential Biological Removal (PBR) has to be estimated and applied on a management unit basis across seasons. However, if it is applied across the coastal morphotype populations in a year then the advantages of running a single, possibly larger survey, in the summer season may lead to better overall estimates. It must be remembered that the evidence used to separate the coastal morphotype into management units is still only preliminary. While the genetic information relating to mitochondrial DNA and to nuclear micro-satellites indicates a degree of separation it also indicates a degree of gene flow between the management units (NMFS, 2001). Complete genetic isolation was not found. In addition, the estuarine populations and their relationship to the inshore coastal populations is also unclear. Unless there are clear reasons not apparent in the review documents for conducting an equal sized survey in the winter (when confounding between management units and coastal and offshore populations is high, and biases appear greater), then an improved summer survey only should be considered seriously.

Otherwise, the surveys and their design appear to have attained a degree of sophistication that means they should achieve their objectives as well as can be expected for line transect surveys of this geographical magnitude.

Spatial Distribution During Aerial Surveys

The objective of this section was to describe any relationships between the observed abundance of bottlenose dolphins and habitat variables during the winter and summer aerial surveys. General Additive Models (GAMs) were used statistically to describe any relationships between dolphin densities (as measured by group numbers) and various habitat variables within 2km squares sampled during the aerial surveys. Using a Geographical Information System (ARCView) the only variables that could be attributed to each 2km spatial cell were depth, distance from shore, and sea-surface temperature. Strictly speaking, the statistical models used were natural splines and not GAMs, as indicated in Tables 1 to 10 in Garrison *et al* (2003). Natural splines actually have an advantage in that GAMS strongly assume that predictor variables have been chosen that are unlikely to have interactions between them. This is clearly not the case between depth and distance from shore so the decision to use natural splines (the function ns in S-Plus) was a good one (Venables & Ripley, 2002).

It is stated (on page 18; Garrison *et al*, 2003) that dolphin groups are the appropriate unit of observation rather than counts of individuals, because groups are expected to respond collectively to environmental variables rather than having separate responses for individual animals. This relies, however, on groups being relatively constant in size once they have formed. In a number of cases (especially, the Northern Migratory management unit - Table 1, and Figures 9, 10, and 11, greater clarity may have derived from considering counts of individuals rather dolphin groups. The single group observed at 37km from shore appears to have been made up of only five animals. In the cubic spline fitted in Figure 9 it is surprising that the single point out wide did not influence the curve beyond a slight increase in confidence intervals. The graphs of group size against distance from shore for the more northerly management units in the summer (e.g. Fig 10) suggest that group size may not only be a function of distance from shore but also of morphotype. That is, that in the northerly management units the offshore bottlenose dolphin only occurs uncommonly and in small groups while the coastal bottlenose dolphin can occur in much larger groups in a more clearly demarked stratum of distance from shore. Neither splines nor GAMs can describe such a disjunction well.

The problem for this section is that, especially in the summer, the distribution of the two morphotypes in the more northerly management units appears to be very clearly demarked by depth and distance from shore. However, the further south one makes observations the more mixed the two groups become. The problem is one of describing a phenomenon that is discrete in the north changing to continuous in the south. The use of GAMs or natural splines to describe this pattern leads to some success but the verbal interpretation of the results in the north appears to reflect the appearance of the data points more than the patterns expressed in the fitted splines. The idea behind these statistical patterns was to provide guidance to the process of quantitatively describing the spatial distribution of the two morphotypes. In the northern management units the GAMs provided no guidance because there was no overlap in the spatial distribution of the morphotypes. If a formal description of the habitat types and the spatial distribution is still required then an alternative approach that could be tried would be to use regression or partition trees. These should provide an optimum partitioning of observations based upon the combined habitat variables. I doubt, however, whether in practice the results would differ appreciably from those already obtained.

The analyses of deviance used and described in Tables 1 to 10 are the standard approach that should be used in such circumstances (Venables & Ripley, 2002). They demonstrate the justification for including each variable or combination of variables.

The relationship between group size and distance from shore or depth is variable from area to area. The relationships fitted are linear regressions fitted between the logarithm of group size against distance from shore. These should really be described as exponential regressions and not linear regressions. In the text, the fact that the regressions are against the log of group size is sometimes forgotten and this can be confusing. For example, on page 22 in the last paragraph it states: "There was a no significant relationship between group size and distance from shore in this unit (linear regression: F = 3.802, error df = 28, model df =1 , p = 0.0610,". I assume that the regression should have been described as between log(group size) and not group size. This potential source of confusion occurs in a number of the management unit descriptions and should be clarified in the final version of the document.

Distribution of Coastal and Offshore Morphotypes.

A major source of uncertainty in earlier assessments was the fact that the distribution of the coastal and offshore morphotypes overlapped to an unknown extent, particularly in the more southern management units. Thus, abundance of bottlenose dolphins in coastal waters can be produced but how much these are biased upwards by the unknown proportion of the offshore population being present means that little confidence could be held in the earlier estimates. To confirm the observed gaps in distribution in the northerly management units and determine the extent of overlap in the southerly units it was necessary to obtain biopsy samples from dolphins throughout their range in coastal waters. Using such information, this section of the report aimed to characterize formally the degree of spatial overlap between the coastal and offshore morphotypes. The statistical method used, logistic regression, was the most appropriate given the type of data. This assumes that there is a declining gradient of relative density of the coastal morphotype and an increased relative density of the offshore morphotypes as the distance from shore increases. The limited data available appears to support this assumption (Figures 28 to 20; Garrison *et al*, 2003) but more information is needed. The limited sample sizes in each management unit meant that separate statistical models could not be developed for each area so similarities among management units were used to combine data sets and produce descriptions for larger scale regions. The northerly management units in the summer were markedly different from the more southerly units so these, at least, had to be separated and this was appropriate. The absence of dolphins to be sampled in intermediate depths in the northerly regions means that the decision to allocate on spatial analysis alone is the correct one and the best available at the current time. If, in the future, dolphin groups are observed in the intermediate depths then biopsy samples should be attempted. However, this distribution pattern appears to be consistent between years so a change would be unexpected.

As stated on page 32: "In winter months, the regional differences in spatial patterns are not as clearly defined as those during the summer." This supports the suggestion that the abundance surveys should focus on the summer months when fieldwork appears more likely to succeed.

The logistic regression analyses were conducted as well as possible given the data available. The degree of uncertainty around the statistical descriptions simply reflects the limited data availability. Indeed, the analyses for Georgia and North Carolina in the winter appear to be at the limit of usability (Table 12, Figures 29 and 30; Garrison *et al*, 2003). The relative value of improving this aspect of uncertainty in the surveys could be determined by making assumptions about how much the curves might be improved (both in their precision and location) and determining how much these changes would influence the overall estimates of dolphin abundance. These would, in turn influence the Potential Biological Removal levels, which might, in turn, remove or induce more pressure on the fishing industry to reduce bycatch mortality. Intuitively, this source of uncertainty appears to be very large and the whole process should be improved by increasing the database of biopsy samples and analyses.

Abundance of Bottlenose Dolphins

This section provides abundance estimates that include both coastal morphotypes and at least some of the offshore morphotype population. These estimates are a step on the way to estimating the size of the coastal morphotype population. The statistical methods used are the standard approaches described by Buckland *et al* (1993) and the basic descriptions of these methods have not changed in the latest edition of this book (Buckland *et al*, 2001).

In the discussion of the perpendicular sighting distance, the authors are correct to identify dolphin groups as the most appropriate unit of detection because in many areas the average group size was relatively large. The authors are also correct in stating that "A potential source of bias in the expected group size is a tendency for larger groups to be more readily observed at larger distances away from the trackline than smaller groups" (Garrison *et al*, 2003, p 39). It is stated that the potential group size bias is accounted for "by correcting the value of E(s) using a regression of log group size against PSD" (Garrison *et al*, 2003, p 39). While this is indeed possible the authors do not state explicitly how they have used this log-transformation in the analysis. It is quite reasonable to state that there was little evidence for a bias relating to group size to sighting distance but it would be better to present this explicitly by illustrating the lack of a relationship between group size and sighting distance. Figures 31 and 32 (sighting probability as function of perpendicular sighting distance; Garrison *et al*, 2003) need to be complemented by an illustration of the group sizes detected at different distances.

The use of cubic splines to describe the probability density of sighting groups provided the authors with a method that retained sufficient flexibility while retaining a close description of the data collected during the particular surveys. Given that the shape of the observed sighting probabilities did not approximate to any of the standard probability density functions, the use of a cubic spline appears to have been an excellent analytical strategy.

Given the arrangement of the observers in the second team on the aircraft (Figure 4; Garrison *et al*, 2003), which included an observer looking vertically below the aircraft, it was surprising that the probability of being sighted on the trackline was not higher for that team. Some commentary discussing this apparently non-intuitive result would improve the defensibility of the document.

In the estimation of perception bias the use of the direct duplicate estimator (DD), along with a bootstrap procedure to estimate uncertainty provided a workable and adequate method of estimation. The use of bootstrapping would be essential under the non-parametric and non-linear conditions of the analysis. In terms of the number of transects available to bootstrap there appear to have been easily sufficient numbers in the shallow stratum (as evidenced in Figure 3, Garrison *et al*, 2003). However, in the outer/deeper stratum the number of available transects appears limited to 3 in Georgia, 5 in South Carolina, 7 in southern North Carolina, and 8 in northern North Carolina. The number of transects used in each stratum could be added to Tables 19 and 24, and there should be some discussion as to the behaviour of the bootstrap estimates when transect numbers were limited. This is not to say that the bootstrap should not be used, only that when, intuitively, its limits of usability are being approached it is necessary to describe the outcomes in some further detail to make them more defensible.

The use of the flexible sighting function and of the two-observer-team approach combined with the Direct Duplicate analysis are undoubted improvements in the analytical approach over the earlier analysis described in Garrison & Yeung (2001).

Garrison *et al* (2003) make the point that the abundance estimates do not include animals occurring inside estuaries that may belong to the coastal stock of bottlenose dolphins. As the estuarine water bodies along the eastern Atlantic sea-board are extensive this is possibly a major source of negative bias. This relates to the possible biases introduced by the imprecise determination of the stock structure (if any) of the coastal morphotype bottlenose dolphin. The spatial behaviour of the bottlenose dolphin appears to be known only approximately. The relations between estuarine populations and inshore populations need to be investigated.

Abundance of Coastal Morphotype of Bottlenose Dolphin

This is the concluding section to the abundance estimation document. It describes how estimates of the abundance of the coastal morphotype are derived from the abundance estimates of bottlenose dolphins in waters from 0 to 40 m being combined with the logistic regressions of species composition or, in the north in summer, the spatial separation apparent in the survey observations. This analytical strategy appears to be the most likely to provide a workable answer. The need for improving the logistic regressions by obtaining further biopsy samples is well recognized and stated in the document. It seems clear that the sometimes large uncertainty associated with the logistic regressions could be greatly improved by increased sampling. At the same time this should provide further samples of value to the study of the stock structure of the coastal morphotype.

Minor Typological Errors

p.xi. Table I: That the confidence intervals are derived from bootstraps should be made clear. In addition, the upper limit for Central Florida should perhaps be 1561.2 and not 15,611.9.

p.1, 2nd para, 5th line “single coastal migratory *stock* occur*r*ing “

p.16, under <u>Methods</u> Statiscal instead of Statistical.

p.22, 3rd line from the bottom: “There was a no significant…” instead of “not significant”.

p.33, under *Summer Samples* Is the statement in error that the closest to shore an offshore morphotype sample was collected was 36.9km from shore “at a depth of 240.6 m”?

p.50, just above equation 4; “costal” instead of coastal;.

Conclusions/Recommendations

Through the text of the review document, I have made a number of suggestions with regard to potential further work, alternative approaches, clarifications and sampling strategy. These include:

- An assessment should be made of whether it is necessary to conduct surveys in the winter period. A consistent trend of the winter population estimates being smaller than the summer estimates, combined with the distribution of the population among the management units being clearer in the summer, and the separation of the coastal and offshore morphotypes also being clearer, suggests that the sampling should focus and be extended in the summer period.
- Uncertainties in the details of the stock structure of the coastal morphotype of bottlenose dolphin (gene flow still appears to occur between management units) could have a strong influence on the design of the aerial surveys. Greater certainty in the spatial description of heterogeneity within the coastal morphotype will permit the surveys to be optimized.
- The present design of the aerial surveys, given the constraints of the scale of the work and the identification difficulties from the air, appears to be excellent. Including the estimate of perception bias greatly improved the population estimates over earlier surveys.
- The analyses used to describe the distribution of the two morphotypes of dolphin (natural splines) appear sensible for the more southerly management units but do not appear to be needed nor do they work well for the northerly management units in the summer.
- In the descriptions of the relationship between group size and distance from shore for each management unit, the regression used is of log of group size against distance from shore. In the text, it is possible to be confused into thinking it is a simple linear regression between group size and distance from shore that is being used. This should be clarified.
- Providing a formal analysis of the distribution of the coastal and offshore morphotypes, by way of logistic regressions, so that the abundance estimates can focus solely on the coastal morphotype, is a great improvement over the earlier analyses. The assumptions of the analysis appear to be met but the data density appears to be at the limit of usability in the analysis of winter biopsies from Georgia and North Carolina (Figures 29 and 30).
- There is a clear and stated need to collect further biopsy samples. These would permit both an improved estimate of the mixed distributions of coastal and offshore morphotypes in the more southerly management units as well as providing more data for the definition of heterogeneity within the coastal morphotype. The decision over whether to conduct surveys in the winter or summer would inform the design of this sampling.
- In the estimation of dolphin abundance section, the use of a regression of log group size against Perpendicular Sighting Distance to correct the value of mean group size – E(s) in equation 7 of the document needs to be explained and described. It would be best to illustrate the lack of a relationship between group size and sighting distance graphically.
- It seems strange that the second group of observers, including one person looking vertically down, should have approximately the same sighting probability function as the first observer group. An explanation should be provided to remove doubts about this apparently non-intuitive result.
- An assessment may need to be made about the potential biases to the abundance estimates that arise through the dolphins in the sometimes extensive estuarine areas being omitted from the surveys.

- For potential sources of bias that could not be included in the assessment, an indication should be made of whether they would lead to risk averse or risk prone estimates.

References

Buckland, S.T., Anderson, D,R,, Burnham, K.P. and J.L. Laake (1993) *Distance sampling: estimating abundance of biological populations.* Chapman and Hall, London. 446 pp. (First Edition)

Buckland, S.T., Anderson, D,R,, Burnham, K.P., Laake, J.L., Borchers, D.L. and L. Thomas (2001) *Introduction to Distance Sampling: Estimating Abundance of Biological Populations*. Oxford University Press. 304 p.

Eguchi, T. (2002) A method for calculating the effect of a die-off from stranding data. *Marine Mammal Science* **18**: 698-709.

Garrison, L.P., Rosel, P.E., Hohn, A., Baird, R., and W. Haggard (2003) Abundance of the coastal morphotype of bottlenose dolphin, *Tursiops truncates*, in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002. NOAA Fisheries, Southeast Fisheries Science Center.

National Marine Fisheries Service (NFMS). June 2001. Preliminary stock structure of coastal bottlenose dolphins along the Atlantic coast of the U.S. Prepared by Staff, Southeast Fisheries Science Center, National Marine Fisheries Service for the Take Reduction Team on Coastal Bottlenose Dolphins in the Western Atlantic.

Palka, D.L. and M.C. Rossman (November 2001). Bycatch estimates of coastal bottlenose dolphin (*Tursiops truncatus*) in U.S. mid-Atlantic gillnet fisheries for 1996 to 2000. National Marine Fisheries Service. Northeast Fisheries Science Center Reference Document 01-15

Venables, W.N. and B.D. Ripley (2002) *Modern Applied Statistics with S*. Springer-Verlag, New York. 495p.

Appendix A: Background material

Anon. June 2001. Preliminary stock structure of coastal bottlenose dolphins along the Atlantic coast of the U.S. National Marine Fisheries Service.

Garrison, L. P., P. E. Rosel, A. Hohn, R. Baird, W. Hoggard. February 2003. Abundance of the coastal morphotype of bottlenose dolphin, *Tursiops truncatus,* in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002. NOAA Fisheries, Southwest Fisheries Science Center.

Garrison, L. and C. Yeung. 15 June 2001. Abundance estimates for Atlantic bottlenose dolphin stocks during summer and winter, 1995. National Marine Fisheries Service.

Garrison, L. June 2001. Seeking a hiatus in sightings for bottlenose dolphins during summer and winter aerial surveys. National Marine Fisheries Service.

Appendix B: Statement of Work

Statement of Work

Consulting Agreement between the University of Miami and Dr. Malcolm Haddon

January 21, 2003

General

NOAA Fisheries', Southeast Fisheries Science Center (SEFSC), Protected Species and Biodiversity Division undertook aerial surveys to estimate abundance of bottlenose dolphin in the Mid-Atlantic during the winter and summer of 2002. In addition, extensive skin biopsy sampling was conducted during 2001 and 2002 to allow genetic identification of coastal vs. offshore morphotype bottlenose dolphins and describe their relative spatial distribution. The intent was to obtain current information on the winter and summer abundance of coastal morphotype bottlenose dolphin management units that are subject to incidental takes (i.e., mortalities) in coastal gillnet fisheries. This information is required by a Marine Mammal Protection Act (MMPA) Take Reduction Team (TRT), which began to deliberate the status of these dolphin populations in a series of meetings in 2002. The TRT will reconvene in early April 2003 to revise previous recommendations for reducing fishery takes of bottlenose dolphins and consider new abundance estimates and other information as appropriate. The SEFSC is requesting that the Center of Independent Experts (CIE) undertake a peer review of the new abundance estimates and the statistical methodology used to develop them from the winter and summer 2002 aerial surveys.

The CIE consultant shall analyze the new mid-Atlantic bottlenose dolphin estimates focusing on the following issues:

5. The appropriateness of the design, execution, and analysis of the aerial surveys used to derive abundance estimates for bottlenose dolphins in the mid-Atlantic.

6. The appropriateness of the statistical methodologies used to distinguish the spatial distribution and habitats of coastal vs. offshore morphotype bottlenose dolphins.

7. The appropriateness of the resulting abundance estimate for coastal morphotype bottlenose dolphins from combined genetic data, spatial distribution information, and aerial survey data.

8. Determine if potential biases have been adequately identified and whether appropriate measures of statistical uncertainty have been included in the resulting abundance estimates.

The consultant shall be provided the report to be reviewed, "Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002." The consultant shall also be provided and may consult extensive background material (listed in Appendix I) to assist in addressing the aforementioned issues.

The consultant shall conclude, in a written report, whether the analyses represent the best available information on which to proceed with protected species management for this population of bottlenose dolphin.

Specific

The consultant's duties shall not exceed a maximum total of two weeks- several days for document review and several days to produce a written report of the findings. The consultant may perform all review, analysis, and writing duties out of the consultant's primary location, as no travel is required. Finally, no consensus report shall be accepted.

The itemized tasks of the consultant include:

1. Reading and considering various supplementary reports (listed in Appendix I) that provide context and background on the bottlenose dolphin abundance surveys;

2. Reading and analyzing the SEFSC report, "Abundance of Mid-Atlantic Coastal Morphotype Bottlenose Dolphin During Winter and Summer 2002";

3. Submitting a written report of findings, analysis, and conclusions. No later than March 1, 2003, submit the written report[1] (see Annex I for formatting structure) addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Sampson, via email to David.Sampson@oregonstate.edu, and to Mr. Manoj Shivlani, via email to mshivlani@rsmas.miami.edu.

Signed____ Date_____________

[1] The written report will undergo an internal CIE review before it is considered final. After completion, the CIE will create a PDF version of the written report that will be submitted to NMFS and the consultant.

ANNEX I: REPORT GENERATION AND PROCEDURAL ITEMS

1. The report shall be prefaced with an executive summary of findings and/or recommendations.

2. The main body of the report shall consist of a background, description of review activities, summary of findings, and conclusions/recommendations.

3. The report shall also include as separate appendices the bibliography of materials provided by the Center for Independent Experts and the Southeast Fisheries Science Center and a copy of the statement of work.

APPENDIX I: BACKGROUND MATERIAL ON BOTTLENOSE DOLPHIN SCIENCE

National Marine Fisheries Service. November 2001. Draft 2002 Stock Assessment Report for the Western North Atlantic Coastal Stock of Bottlenose Dolphin (Tursiops Truncatus).

National Marine Fisheries Service. September 2000. 2000 Stock Assessment Report for the Western North Atlantic Coastal Stock of Bottlenose Dolphin (Tursiops Truncatus).

Atlantic Scientific Review Group review of Bottlenose Dolphin documents. October 2001.

NMFS response to the Atlantic Scientific Review Group. November 2001.

Comments from one member of the Team for the CIE peer review. December 2001.

Letter from Rick Marks to the Honorable James V. Hansen and the Honorable Don Young of the U.S. House of Representatives Resources Committee regarding the bottlenose dolphin take reduction team process. August 2001.

NMFS response to Rick Marks letter to the House Resources Committee. September 2001.

Palka, D., F. Wenzel, D. L. Hartley, and M. Rossman. June 2001. Summary of bottlenose dolphin strandings from New York to Virginia.

Hohn A., P. T. Martone. July 2001. Characterization of bottlenose dolphin strandings in North Carolina, 1997-2000.

Hohn A., B. Mase, J. Litz, W. McFee, and B. Zoodsma. November 2001. Characterization of human-caused strandings of bottlenose dolphins along the Atlantic coast from South Carolina to Florida, 1997-2000.

References on Stock Structure

National Marine Fisheries Service. June 2001. Preliminary stock structure of coastal bottlenose dolphins along the Atlantic coast of the U.S.

Garrison, L. June 2001. Seeking a hiatus in sightings for bottlenose dolphin during summer and winter aerial surveys. National Marine Fisheries Service.

Garrison, L. and A. Hohn. October 2001. Abundance estimates for Atlantic bottlenose dolphins: combining strip transect data and line transect abundance estimation. National Marine Fisheries Service.

Garrison, L. and C. Yeung. 15 June 2001. Abundance estimates for Atlantic bottlenose dolphin stocks during summer and winter, 1995. National Marine Fisheries Service.

Palka, D., L. Garrison, A. Hohn, and C. Yeung. 1 November 2001. Summary of abundance estimates and PBR for coastal *Tursiops* for waters between New York and Florida during 1995 to 2000. National Marine Fisheries Service.

Garrison, L. 2 July 2001. Mortality estimate for Atlantic bottlenose dolphin in the directed shark gillnet fishery of Florida and Georgia. National Marine Fisheries Service.

Rossman, M. and D. Palka. 3 October 2001. Bycatch estimates of coastal bottlenose dolphin (Tursiops truncatus) in U.S. mid-Atlantic gillnet fisheries for 1996 to 2000. National Marine Fisheries Service.